The CAPMS Project

Multiple Approaches to Air Quality Benefits Analysis

Leland Deck, Ph.D.
Vice President
Abt Associates Inc.

Abt Associates Inc.

Abt Associates' Air Quality Benefits Models

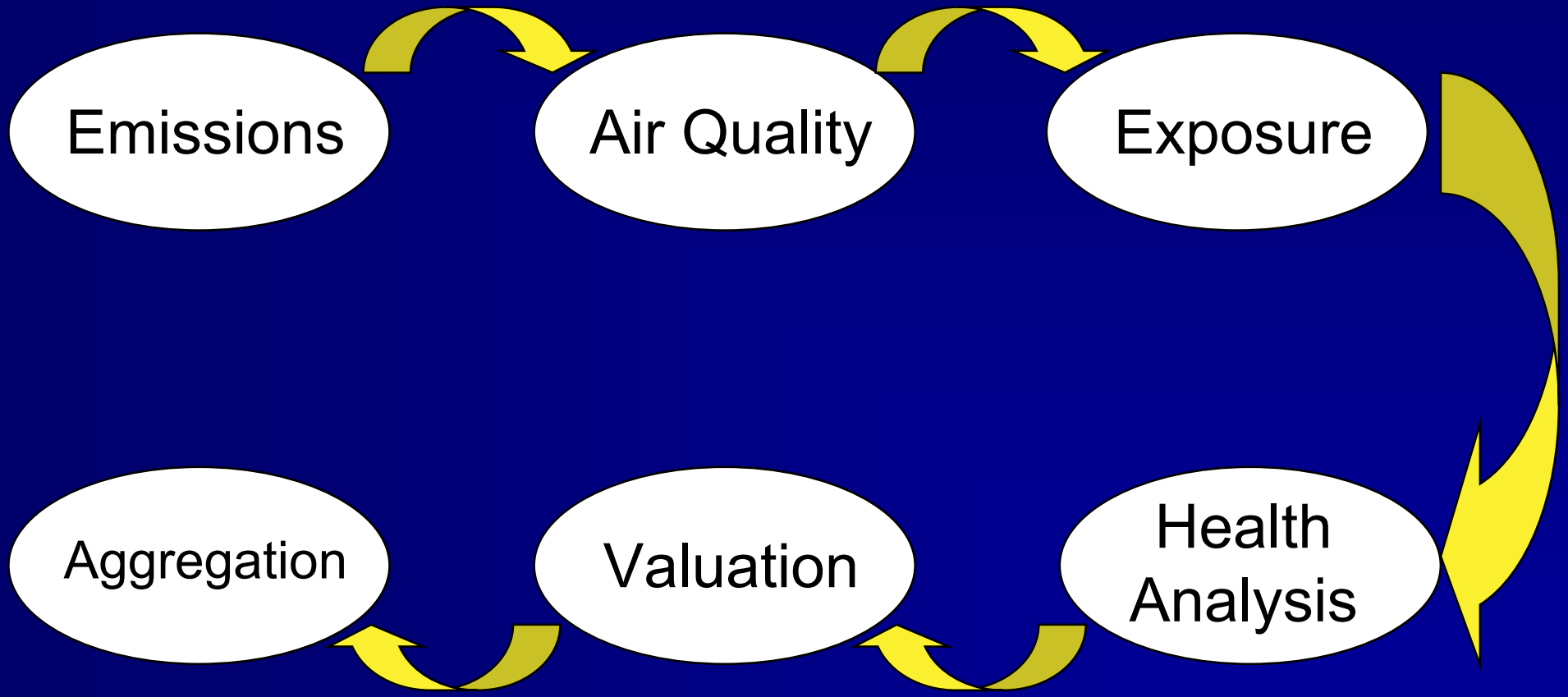
Linking Models

- Work directly or indirectly with other complex models
- CAPMS: Criteria Air Pollutant Modeling System
- Currently under revision for Public Release as BENMOD / CAPMS III

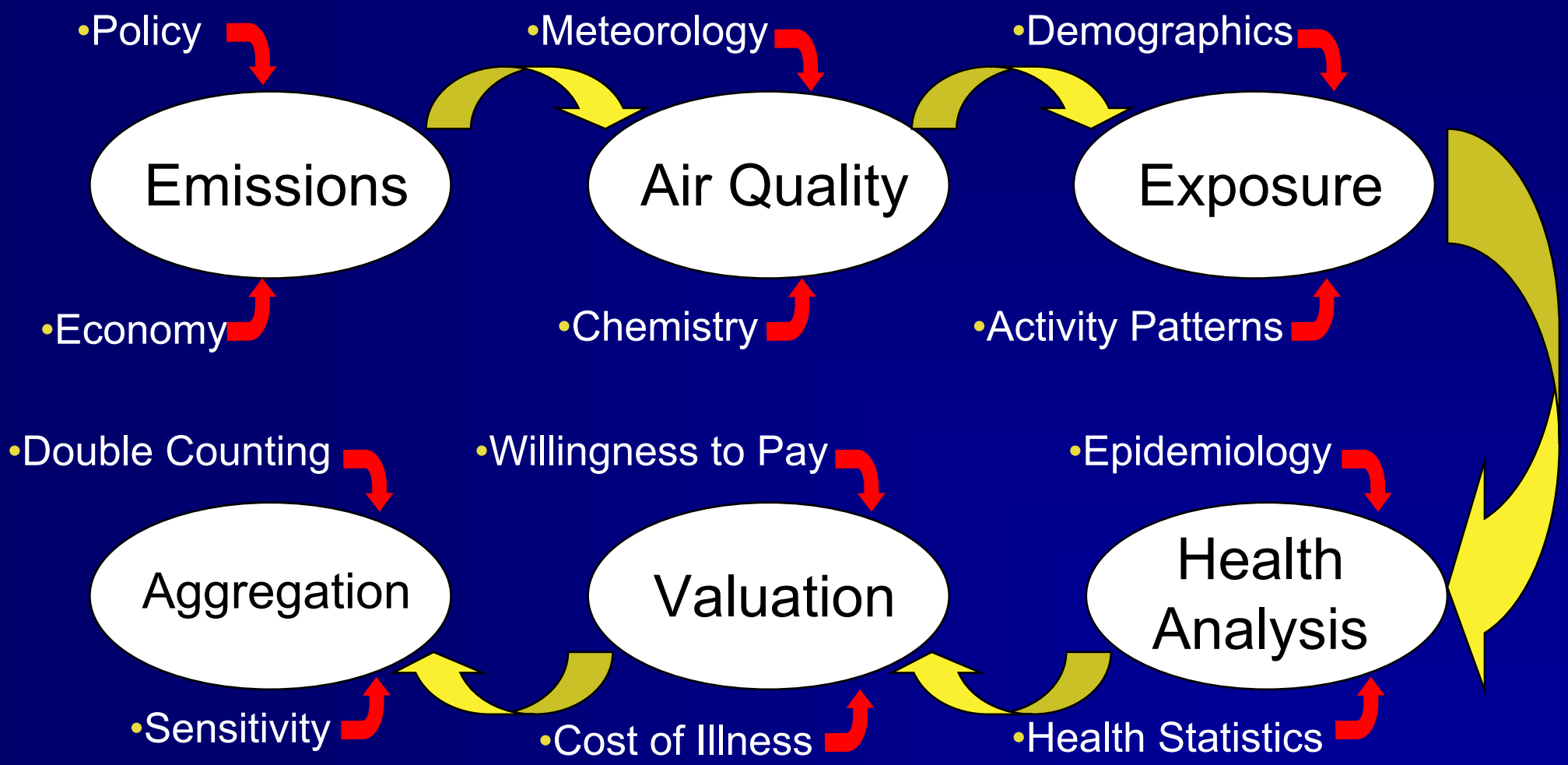
Integrated Models

- Perform wider span of analytical functions
- Key criteria: internal estimation of air quality changes
- Two examples presented today
- COBRA, the New York State Co-Benefits Risk Assessment Model
  - PM model of all emission sectors in New York State
  - Nationwide air quality changes
- BRAVE, the Benefits of Reducing Annual Vehicle Emissions

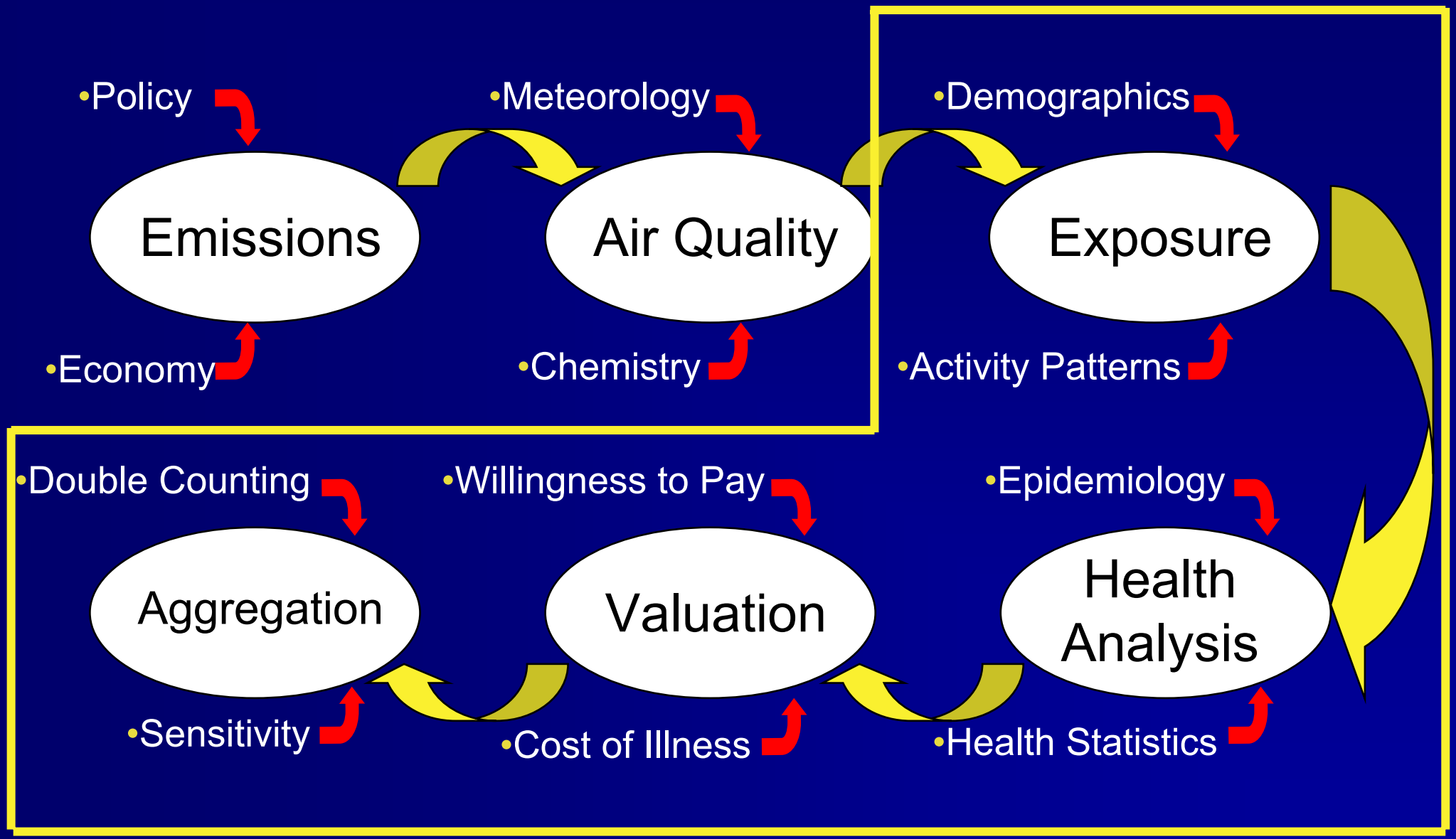
Air Benefits is Inherently Multi-Disciplinary



Air Benefits is Inherently Multi-Disciplinary

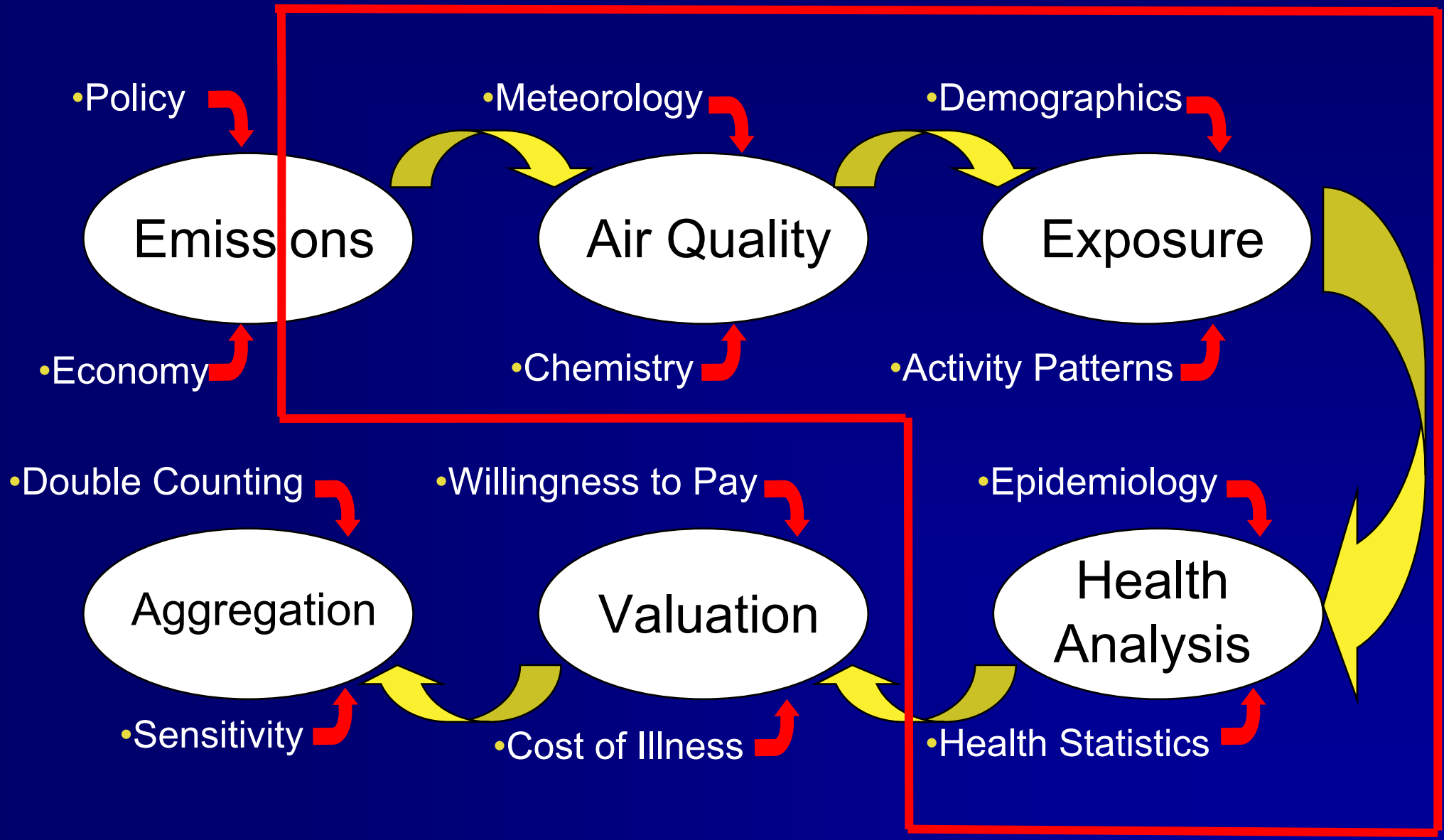


CAPMS: A Linking Model



CAPMS

COBRA & BRAVE: Integrated Models



LINKING MODELS: CLEAR SKIES ANALYSIS

Policy Change

Electricity Model: Integrated Planning Model

- Dispatch, Refueling, Retirements, New Units

All Other Emissions

- Mobile 6, All Other Sectors

Meteorology

Environmental Fate & Transport

- REMSAD (PM) & CAMx (Ozone)

CAPMS

- Relative AQ Adjustments, Population Growth, Exposure, Health Effects, Valuation, Alternative Analyses, Quantified Uncertainty

Agricultural Loss Model (AGSIM), Forestry Model (TAMM)

CAPMS: A Linking Model Approach

US EPA Primary Air Benefits Model

- 1997 Ozone and PM NAAQS
- §812 Reports to Congress: Benefits/Costs of Clean Air Act
- 1998 NOx SIP Call (Eastern Power Plant Emissions)
- 1999 Tier II Automobile Tailpipe Standards
- 2000 Heavy Duty Diesel Rule
- 2002 Clear Skies Initiative
- Currently: Off-Road Diesel Vehicles

Non-EPA Analysis

- California (Cal-CAPMS), Southern Appalachian Mountain Initiative
- Legislative Analysis: Clean Smokestacks Act (Waxman Bill)

Extensive Peer Review & Public Comment

CAPMS COMPONENTS: AIR QUALITY

Direct Read-in of Air Quality Model Outputs

- REMSAD: PM, ~10,000 grid cells, 365 days
- CAMx: Ozone (and PM) ~75,000 grid cells, hourly x 365 days
- UAM-V: Ozone ~75,000 grid cells, hourly x 365 days
- County and Monitor-based
- Learning Mode for new AQ Models

Absolute or Relative Air Quality Analysis

- Absolute uses AQ model results directly
- Relative combines Monitor data and AQ model

GIS Component: Export Data and Maps

Abt

CAPMS COMPONENTS: POPULATION

Based on 2000 Census Block Data

CAPMS Matches Grid Cells of Air Quality Models

- **Divides to get accurate County/State reporting**

Includes Age, Gender, Race, Income information

Uses Woods & Pool estimates of future years (to 2025)

- **Includes changes in age/race/gender demographics**

Abt

CAPMS COMPONENTS: HEALTH ANALYSIS

Large Library of Concentration-Response Functions

- 18 Broad Health Categories, 521 Functions
- Age, gender, race specific
- User may add new functions

Most Functions are Relative Risk Functions

- A change of x $\mu g/m^3$ of PM2.5 leads to y % change in hospital admissions
- Using these to predict changes in the incidence requires baseline incidence rates

Baseline Incidence Rates

- County-specific wherever possible: Age/Gender/Race for mortality
- Region-specific for Hospital Admissions (age & gender)
- National where necessary

Abt

CAPMS COMPONENTS: VALUATION

Large Library of Valuation Functions

- Each Health Endpoint has at least one valuation function
- Some have alternative valuations
- Some are Preference-Based (Willingness to Pay)
- Some are Cost of Illness Based (Hospital Admissions)
- Some are value of time (wage rate) based: Work Loss Days

CAPMS COMPONENTS:
AGGREGATION, SENSITIVITY & UNCERTAINTY

Aggregation major concern to avoid double counting

- User may specify how to aggregate
- Meta-Analysis included (Random and Fixed Effects Weights)
- User-specified weights allowed (subjective or external weights)

Sensitivity & Alternative Analyses

- Speed of CAPMS allows multiple analyses
- E.g., alternative air quality models, alternative sets of assumptions

Monte Carlo Uncertainty Analysis

- Performs integrated Monte Carlo analysis on quantified uncertainty and/or variability
- Health estimation and valuation
- National where necessary

Abt

Integrated Models: COBRA & BRAVE

Models estimate changes in PM2.5 concentrations & Health Analysis of user-specified emission changes

COBRA: The Co-Benefits Risk Assessment Model

- Under development for US EPA Climate Change Program
- New York State: Emissions from all Sectors

BRAVE: Benefits from Reducing Annual Vehicle Emissions

- Under development for Clean Air Task Force
- National inventory of emissions from 25 mobile emission sectors

Includes simple PM Air Quality Model: The S-R Matrix

Includes limited set of PM-related Health Effects

The S-R Matrix PM Model

Developed by EPA for Policy Analysis

- Widely used throughout ’90s for regulatory analysis
  - ’97 PM NAAQS
  - ’98 NOx SIP Call
  - ’99 Regional Haze Rule
  - ’99 Tier II Automobile Tailpipe Standards (1 of 2 models)
  - ’02 Internal Combustion Engine and Industrial Boiler NESHAP
- Fast and inexpensive to run
- Screening and policy analysis tool: Never used for Non-attainment analysis

County-to-County Secondarily formed PM model

- Includes 6 pollutants
- Model estimates contribution of Area, Mobile & low industrial
- ~2000 Tall Stacks modeled separately

Abt

COBRA: New York State Emission Model

2007 Inventory of New York State

- County Level Emission Inventory
- Six Pollutants
  - SO2, NOx, VOC, Direct PM Coarse, Direct PM Fine, Ammonia, VOC
- 14 Broad Economic Categories
  - E.G., Electric utility, highway vehicles, solvent usage, metals processing
- Further subdivided into 67 Emission categories
  - Bulk materials storage, polymers and resins, coal electricity generation
  - Still further divided into 101 Tier III categories: fuel specific
- Total of ~6,000 County/Economic/Emission categories
  - Not all counties have all categories: from 67 to 172 in 63 different counties

Abt

COBRA: Health Effects

9 Different PM-related Health effects

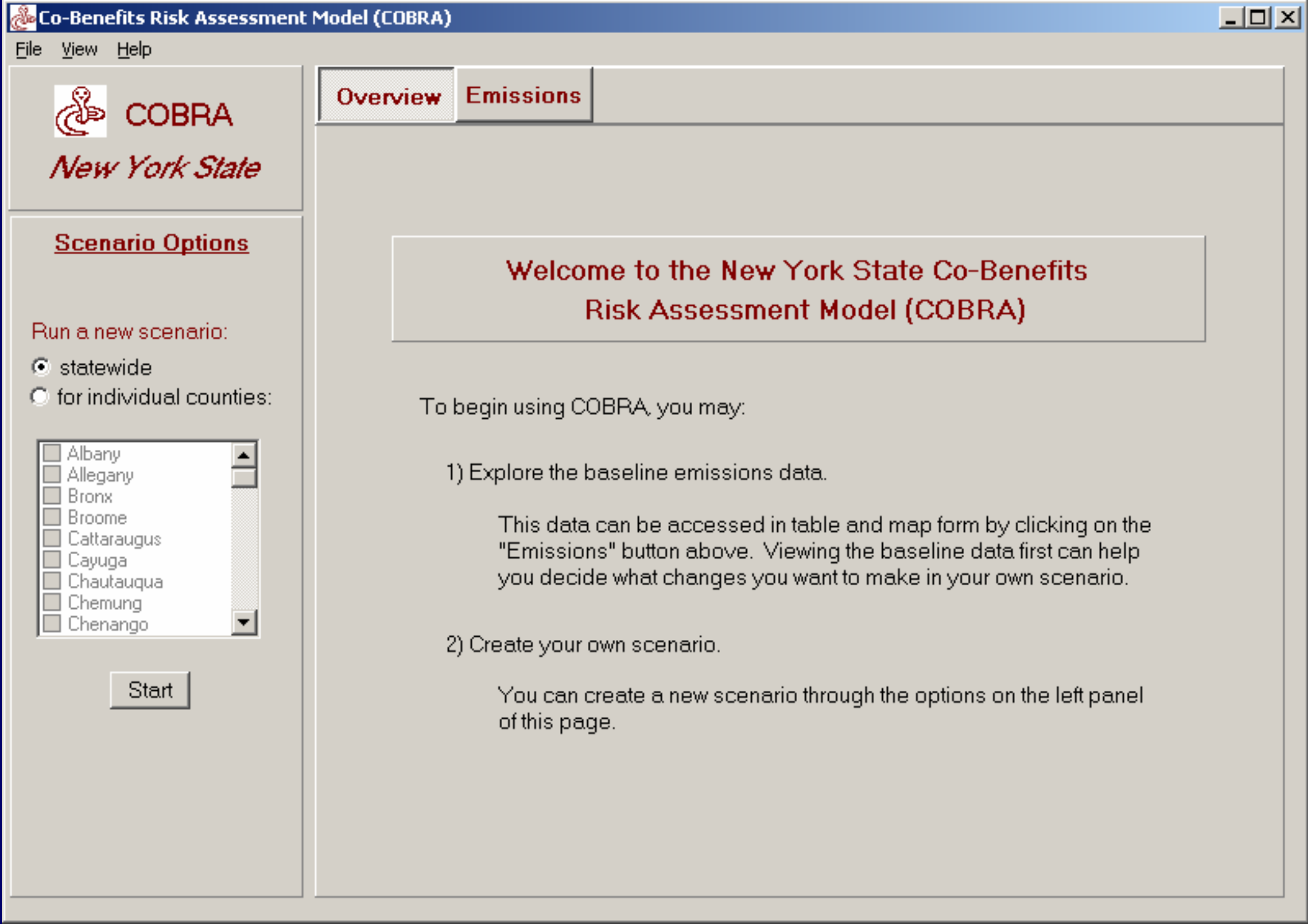
- Premature Mortality
- Chronic Bronchitis
- 2 Types of Hospital Admissions
  - Respiratory and Cardio-Vascular
- 3 Types of Daily Illness
  - Asthma attacks, Upper Respiratory Disease, Lower Respiratory Disease
- 2 Types of "Bad Days"
  - Minor Restricted Activity Days (MRADs)
  - Work Loss Days

COBRA: User Can Define Scenario

User may specify Emission Reductions

- Either Percent Reduction or # tons reduced
- Individual counties, groups of counties, or statewide
- Specify which emission categories you want to control

Although emissions are only within New York, PM level changes and health effects are nationwide


Co-Benefits Risk Assessment Model (COBRA)
File View Help
COBRA
New York State
Scenario Options
Run a new scenario:
statewide
for individual counties:
Albany
Allegany
Bronx
Broome
Cattaraugus
Cayuga
Chautauqua
Chemung
Chenango
Start
Overview
Emissions
Welcome to the New York State Co-Benefits Risk Assessment Model (COBRA)
To begin using COBRA, you may:
1) Explore the baseline emissions data.
This data can be accessed in table and map form by clicking on the "Emissions" button above. Viewing the baseline data first can help you decide what changes you want to make in your own scenario.
2) Create your own scenario.
You can create a new scenario through the options on the left panel of this page.

Co-Benefits Risk Assessment Model (COBRA)

File View Help

COBRA

New York State

Base Emissions Table Options

Current table:

Data for: New York State

Divided by: County

View new table by:

---choose view---

View

Overview | Emissions | Scenario 1 | Scenario 2 | Scenario 3

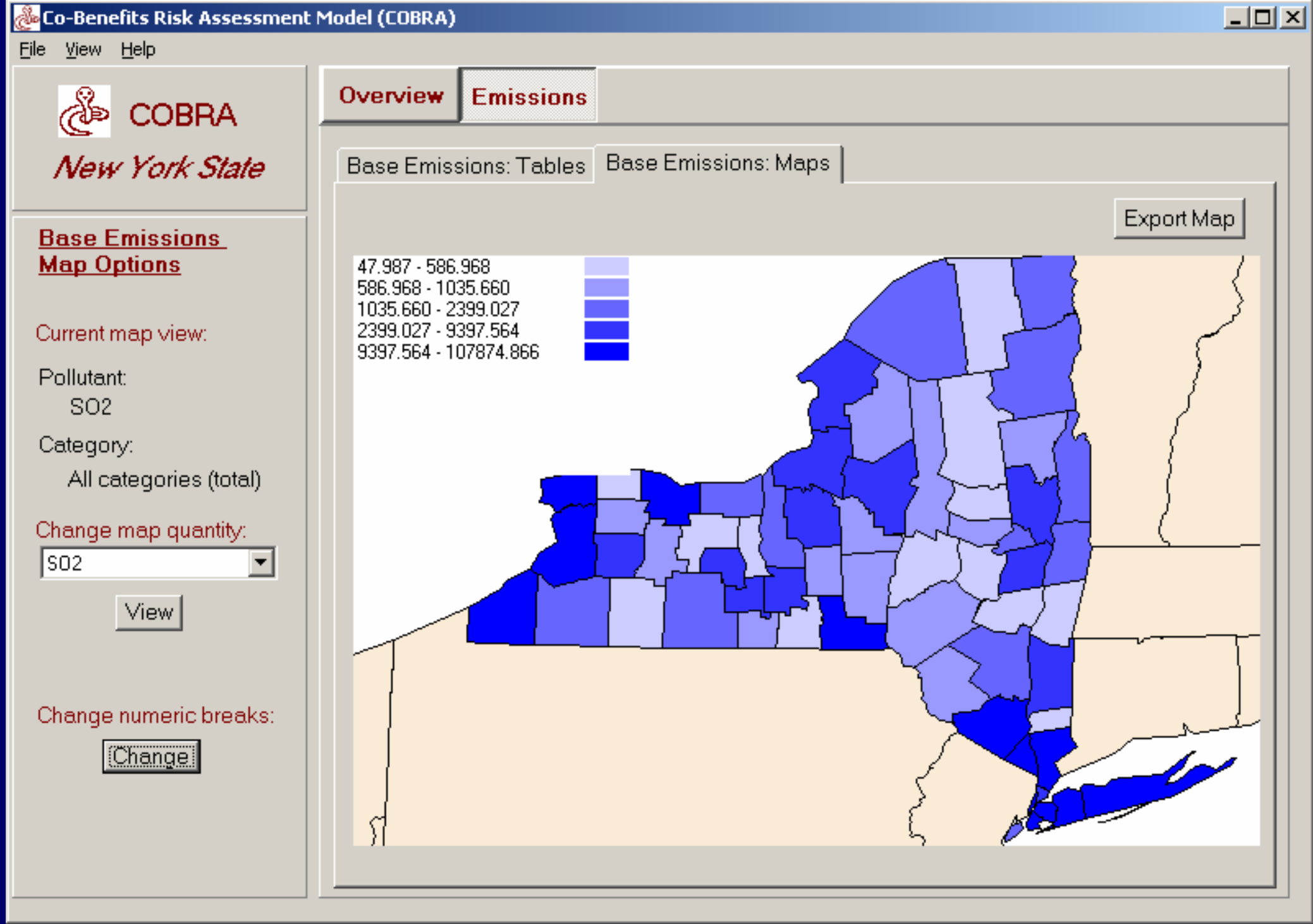
Base Emissions: Tables | Base Emissions: Maps

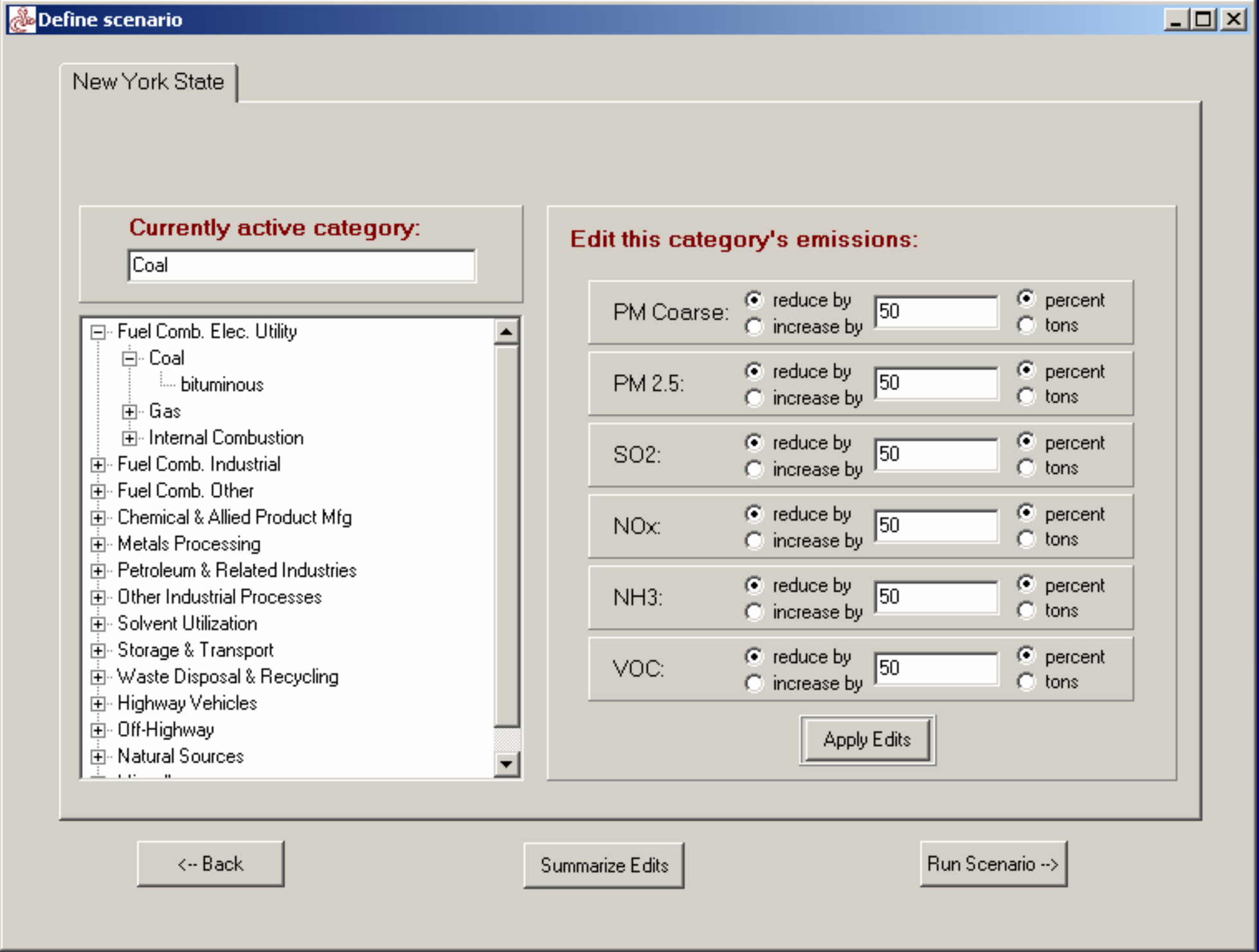
Summary of data for: New York State

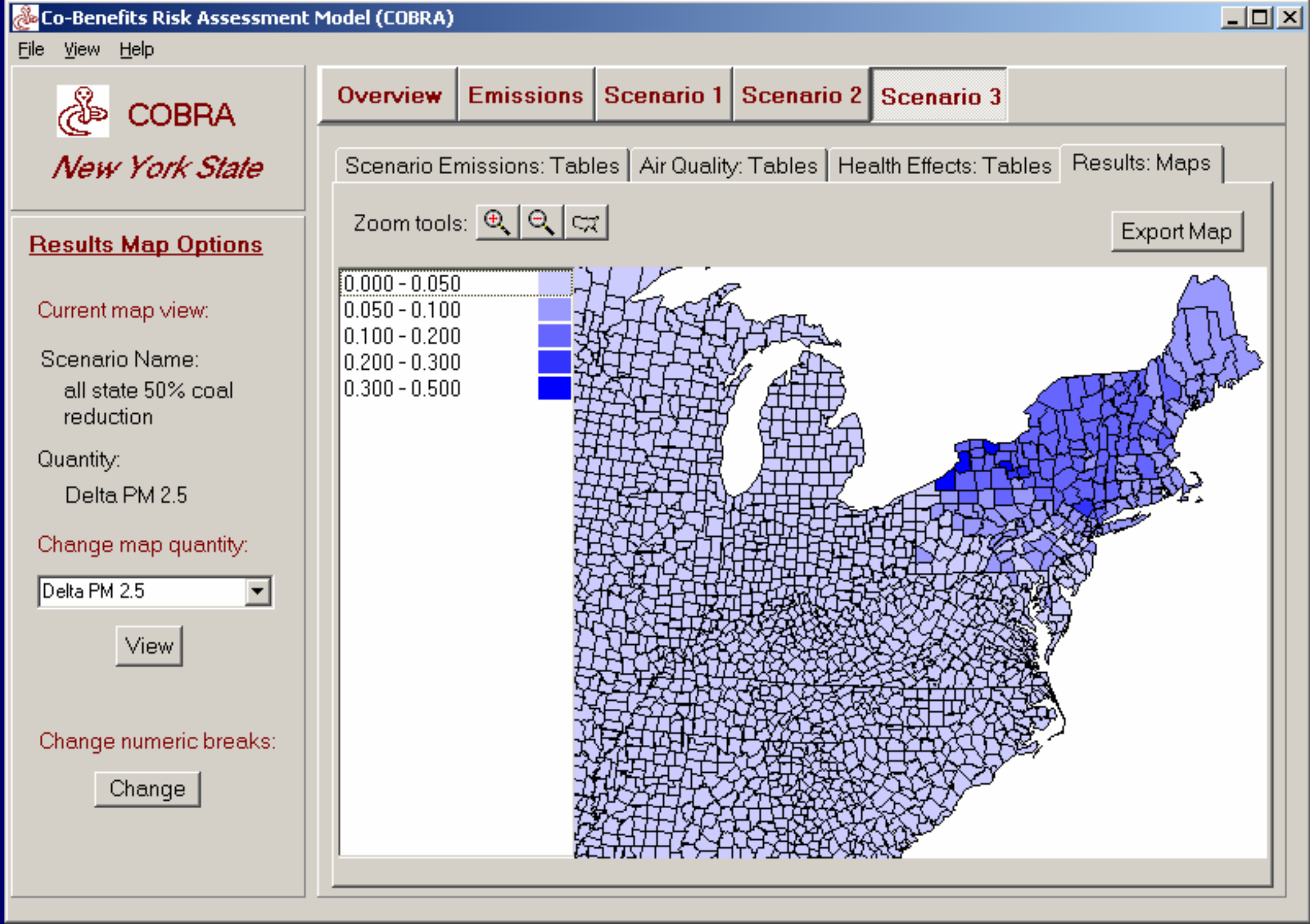
Export All Emissions Data

COUNTY	PMC	PM25	SO2	NOX	NH3	VOC
State Total	225651.4657	141273.9555	507982.1261	531564.5585	68613.3838	549061.7
Albany	8452.8006	18944.9667	4438.5319	12943.0738	882.3121	11393.3
Allegany	1346.2815	701.6243	409.8438	2154.7623	913.3692	1898.8
Bronx	8350.7601	5102.586	9397.5637	18164.6718	1277.7002	17693.4
Broome	4814.1393	2203.8116	10061.3227	9290.6522	882.9689	10350.5
Cattaraugus	2045.3502	1267.8117	1193.2543	3719.3793	1163.4083	4381.
Cayuga	2031.0982	1329.592	1118.6099	3272.2078	1677.2436	2777.5
Chautauqua	2500.4265	1481.7563	52402.4006	10834.7538	1585.8803	7706.0
Chemung	1440.2354	736.4414	1035.6597	3162.6077	669.4696	3890.
Chenango	1453.191	804.4342	973.4985	2235.5408	1175.3571	2107.0
Clinton	2043.2045	1231.1936	1897.7732	4135.8875	1098.11	3264.7
Columbia	1650.8051	667.9596	487.8	2472.8282	843.6555	2269.2
Cortland	1092.6998	575.6597	612.0054	1513.0054	862.1646	2133.7
Delaware	1186.9601	706.9209	631.8872	1873.7514	967.5749	2396.6

Note: All values are in tons of emissions. Data represent estimates for 2007.


Co-Benefits Risk Assessment Model (COBRA)
File View Help
COBRA
New York State
Overview
Emissions
Base Emissions: Tables
Base Emissions: Maps
Export Map
Base Emissions Map Options
Current map view:
Pollutant:
SO2
Category:
All categories (total)
Change map quantity:
SO2
View
Change numeric breaks:
Change
47.987 - 586.968
586.968 - 1035.660
1035.660 - 2399.027
2399.027 - 9397.564
9397.564 - 107874.866


Define scenario
New York State
Currently active category:
Coal
Fuel Comb. Elec. Utility
Coal
bituminous
Gas
Internal Combustion
Fuel Comb. Industrial
Fuel Comb. Other
Chemical & Allied Product Mfg
Metals Processing
Petroleum & Related Industries
Other Industrial Processes
Solvent Utilization
Storage & Transport
Waste Disposal & Recycling
Highway Vehicles
Off-Highway
Natural Sources
Edit this category's emissions:
PM Coarse: reduce by increase by 50 percent tons
PM 2.5: reduce by increase by 50 percent tons
SO2: reduce by increase by 50 percent tons
NOx: reduce by increase by 50 percent tons
NH3: reduce by increase by 50 percent tons
VOC: reduce by increase by 50 percent tons
Apply Edits
<-- Back
Summarize Edits
Run Scenario -->


Co-Benefits Risk Assessment Model (COBRA)
File View Help
COBRA
New York State
Overview
Emissions
Scenario 1
Scenario 2
Scenario 3
Scenario Emissions: Tables
Air Quality: Tables
Health Effects: Tables
Results: Maps
Results Map Options
Current map view:
Scenario Name:
all state 50% coal reduction
Quantity:
Delta PM 2.5
Change map quantity:
Delta PM 2.5
View
Change numeric breaks:
Change
Zoom tools:
Export Map
0.000 - 0.050
0.050 - 0.100
0.100 - 0.200
0.200 - 0.300
0.300 - 0.500

Co-Benefits Risk Assessment Model (COBRA)

File View Help

COBRA

New York State

Health Effects Table Options

Current table:

Scenario Name:
all state 50% coal reduction

View:
All States

View new table by:

All States

View

Overview | Emissions | Scenario 1 | Scenario 2 | Scenario 3

Scenario Emissions: Tables | Air Quality: Tables | Health Effects: Tables | Results: Maps

Export Table

County	Mortality	Chr...	Resp_hosp	CV_hosp	UpperResp...	LowerResp_Symp
Onondaga	2.655	2.154	1.43	1.485	73.658	64.262
Middlesex	2.817	2.256	1.433	1.376	63.762	66.46
Cook	1.81	2.516	1.533	1.401	93.444	48.487
Orange	3.116	2.604	1.496	1.35	105.82	102.172
Westchester	3.456	2.67	1.764	1.749	85.342	88.654
Bronx	4.496	2.829	1.831	1.609	134.295	139.457
Nassau	4.045	3.162	2.19	2.24	97.678	101.367
New York	4.21	3.548	2.211	2.112	77.698	80.535
Suffolk	4.713	3.704	2.278	2.154	123.583	128.382
Queens	6.455	4.968	3.23	3.097	152.874	158.616
Kings	7.156	5.052	3.344	3.112	190.306	197.459
Monroe	7.666	5.697	3.755	3.674	199.772	199.928
Erie	16.878	10.34	7.538	7.884	318.992	321.584
	230.73	164.14	107.73	103.40	5300.67	5346.50

Note: All values represent the change in health effect. Data represent estimates for 2007.

BRAVE: National Vehicle Emissions Model

Similar to COBRA, except nationwide inventory of vehicle emissions

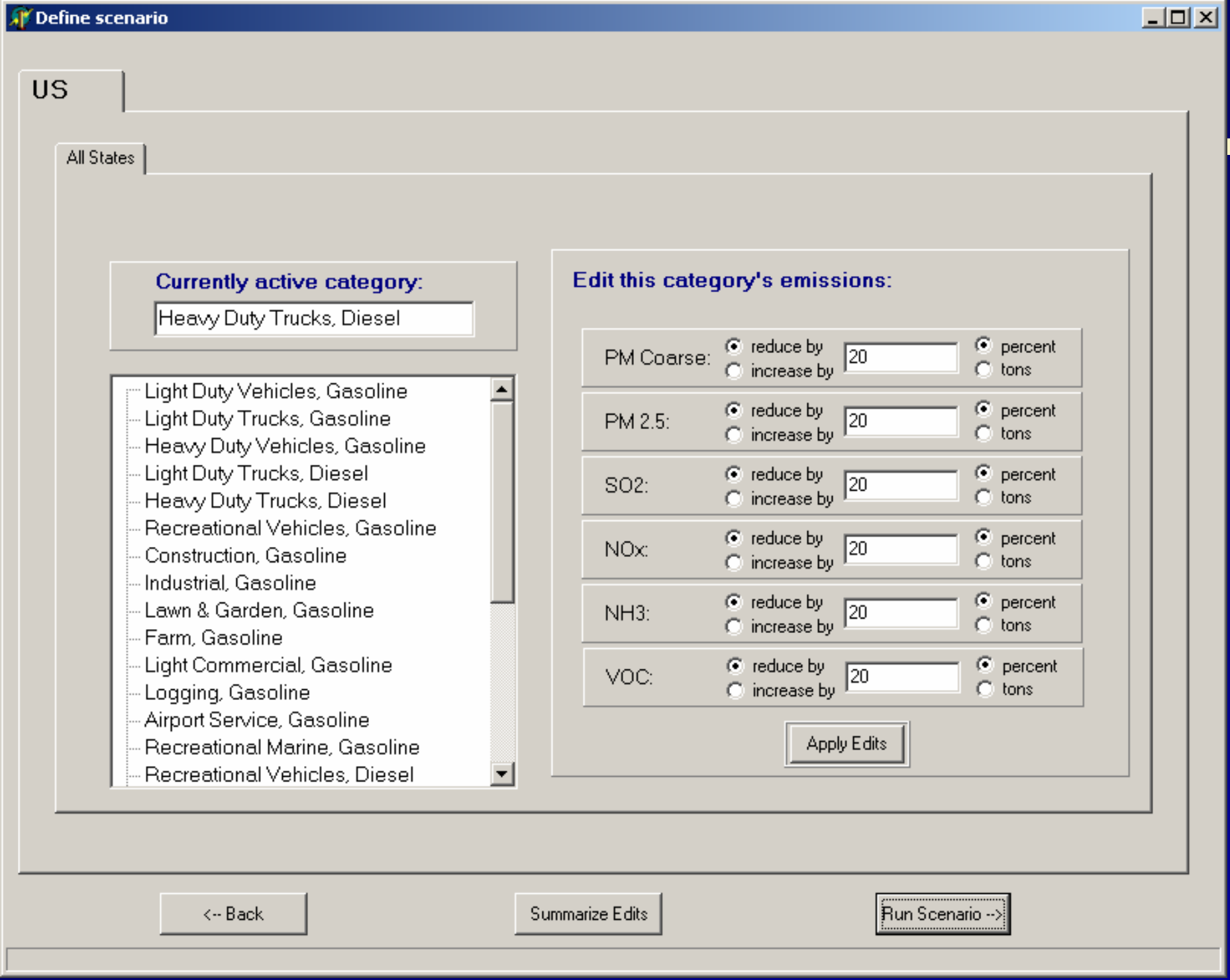
National Inventory including all Counties

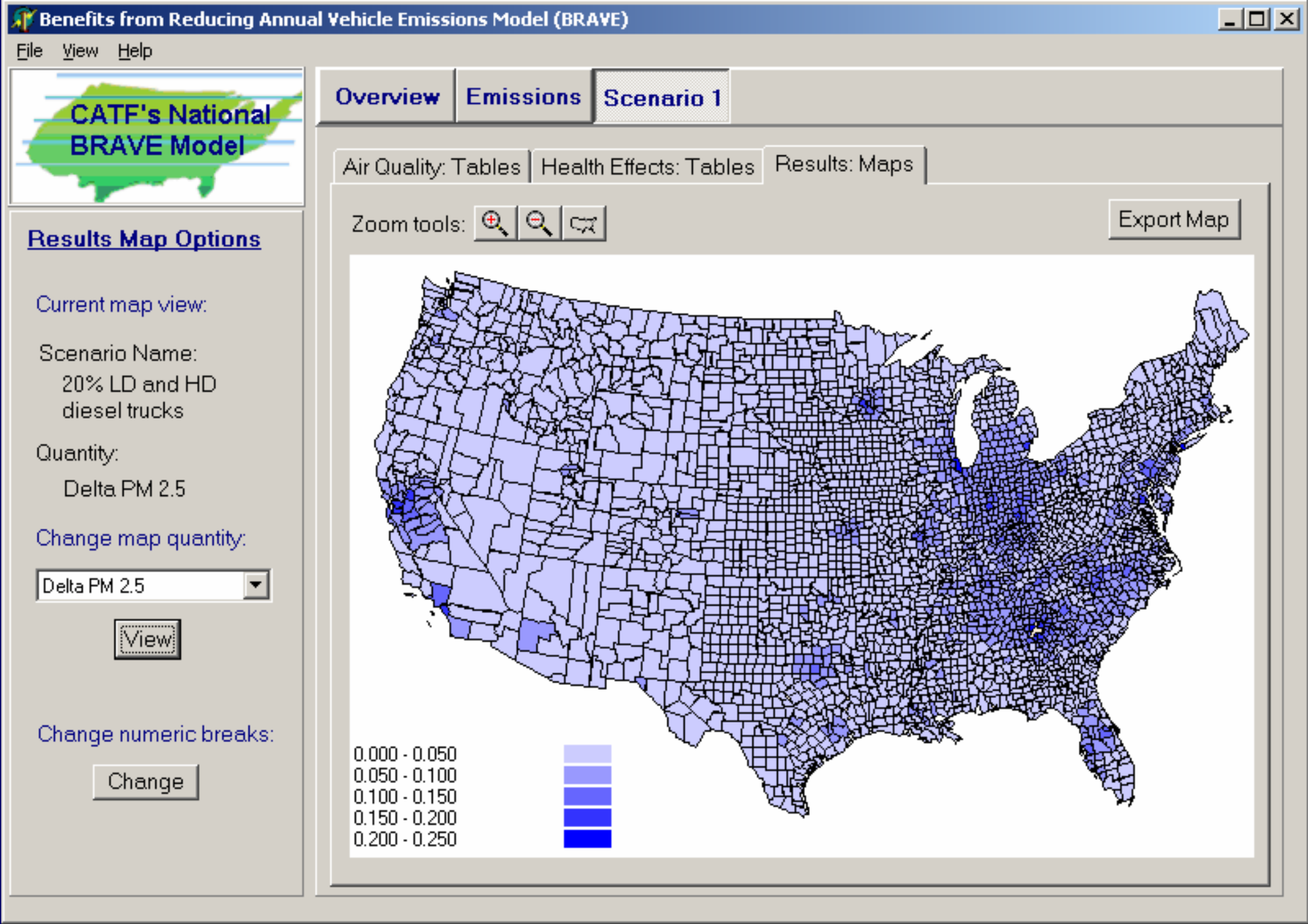
25 Different Vehicle Categories

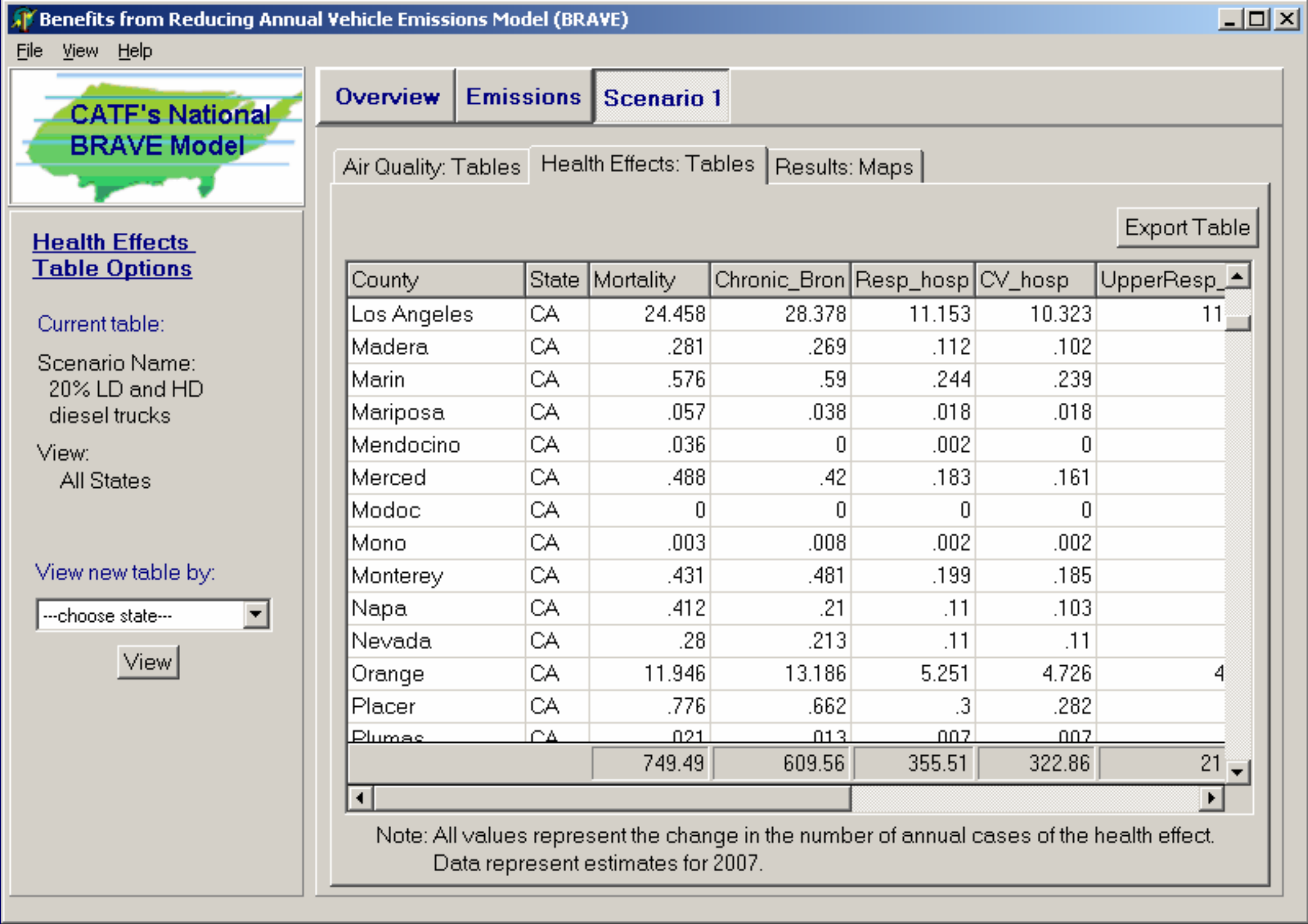
- **12 Gasoline (cars, trucks, RVs, lawn tractors, farm, commercial, rec. boats, etc.)**
- **10 Diesel (Light & Heavy Duty Trucks, RVs, farm, airport service, etc.)**
- **Aircraft, Marine, Railroad**

Total of ~77,000 County/Fuel/Engine/Vehicle categories

Abt


Define scenario
US
All States
Currently active category:
Heavy Duty Trucks, Diesel
Light Duty Vehicles, Gasoline
Light Duty Trucks, Gasoline
Heavy Duty Vehicles, Gasoline
Light Duty Trucks, Diesel
Heavy Duty Trucks, Diesel
Recreational Vehicles, Gasoline
Construction, Gasoline
Industrial, Gasoline
Lawn & Garden, Gasoline
Farm, Gasoline
Light Commercial, Gasoline
Logging, Gasoline
Airport Service, Gasoline
Recreational Marine, Gasoline
Recreational Vehicles, Diesel
Edit this category's emissions:
PM Coarse:
PM 2.5:
SO2:
NOx:
NH3:
VOC:
reduce by
increase by
20
percent
tons
Apply Edits
<-- Back
Summarize Edits
Run Scenario -->


Benefits from Reducing Annual Vehicle Emissions Model (BRAVE)
File View Help
CATF's National BRAVE Model
Overview
Emissions
Scenario 1
Air Quality: Tables
Health Effects: Tables
Results: Maps
Zoom tools:
Export Map
Results Map Options
Current map view:
Scenario Name:
20% LD and HD diesel trucks
Quantity:
Delta PM 2.5
Change map quantity:
Delta PM 2.5
View
Change numeric breaks:
Change
0.000 - 0.050
0.050 - 0.100
0.100 - 0.150
0.150 - 0.200
0.200 - 0.250



County	State	Mortality	Chronic_Bron	Resp_hosp	CV_hosp	UpperResp_
Los Angeles	CA	24.458	28.378	11.153	10.323	11
Madera	CA	.281	.269	.112	.102	
Marin	CA	.576	.59	.244	.239	
Mariposa	CA	.057	.038	.018	.018	
Mendocino	CA	.036	0	.002	0	
Merced	CA	.488	.42	.183	.161	
Modoc	CA	0	0	0	0	
Mono	CA	.003	.008	.002	.002	
Monterey	CA	.431	.481	.199	.185	
Napa	CA	.412	.21	.11	.103	
Nevada	CA	.28	.213	.11	.11	
Orange	CA	11.946	13.186	5.251	4.726	4
Placer	CA	.776	.662	.3	.282	
Plumas	CA	.021	.013	.007	.007	
		749.49	609.56	355.51	322.86	21

Abt Associates Inc.